Figure 6. Briefly stated, the valve body is designated by 120, the relief opening is denoted by 121, the throat tube and associated parts are indicated by 122, the flanged opening to the atmosphere by 123, the frame rods by 124 and 125, the guide by 126, the adjusting ring for the guide by 127, the locking nut for the adjusting ring by 128, the studs by 129, the nuts for the studs by 130 and 131, the piston by 132, the spindle by 133, the spring by 134, the sleeve for the spring by 135, the pressure or adjusting screw by 136, the cross-rod by 137, the bonnet by 138, the operating lever by 139, the deflector plate by 140 and the valve disk by 141. The reference numeral 142 indicates an adjustable indicator that may be used to indicate the lift of the valve. The numeral 143 designates the exhaust chamber, 144 and 145 denote two of the exhaust ports, and 146 denotes a metering valve for one of the ports 144. The other port instead of being provided with a metering valve is in alinement with a tube 147 which may be formed integrally with the body of the valve. The port 145 may be one of the two ports that are not normally provided with metering valves, in which case the tube 147 would be at right angles to metering valve 146 instead of being opposite thereto as shown. The tube 147 may advantageously be provided with a flange 148 so that the tube 147 may be readily connected with a second tube 149 leading to the operating lever of a pilot-actuated valve. For this purpose, the second tube 149 may also be provided with a flange 150. Instead of the illustrated flanged connections, screwed connections may be used, if so desired, as the pressure developed in the actuating line is rather low.

Any of the embodiments of the invention that have been described as well as any conventional form of safety valve may be modified in construction so as to be actuated by the jet of steam issuing from the exhaust port of the pilot valve of Figure 11. It is merely necessary to provide the valve to be actuated by the pilot valve with means actuated by the jet of steam to raise the operating lever and hence the valve disk independently of the pressure below the valve disk.

In Figure 12 is illustrated a form of valve similar to the valve of Figure 6 modified in construction to adapt it for use as a pilot-actuated valve. The valve body is indicated by 151, the relief opening by 152, the flanged opening to the atmosphere by 153, the throat tube assembly by 154, the guide by 155, the adjusting ring for the guide by 156, the deflector plate by 157, the valve disk by 158, the piston by 159, the spindle by 160, the spring by 161, the sleeve for the spring by 162, the spring washer by 163, the pressure or adjusting screw by 164, the nozzle ring for the throat tube by 165, the locking screw for the nozzle ring by 166, the exhaust belt by 167, the exhaust ports by 168 and the metering valves by 169. All of the foregoing elements are substantially of the same construction as the corresponding elements shown in Figure 6.

In Figure 12, the numeral 170 denotes a modified form of cross-bar or yoke provided with an extension 171 for supporting the cylinder 172. The cylinder has a reduced upper portion 173 which fits snugly in an aperture provided in the extension, a part of 173 extending above the aperture and being provided with screw threads to receive a nut 174 to secure the cylinder in position. The numeral 175 denotes a lock nut of suitable construction provided with a key in the form of a cotter pin 176.

Mounted for vertical slidable movement within the cylinder 172 is a piston 177 provided with a vertical pin 178, which projects above the lock nut 175 and is normally in contact with the undersurface of the operating lever 179. The lever may be provided with a cam surface 180 as shown to coact with the pin 178. The lever is fulcrumed at 181 in the bonnet 182 of the valve and contacts the lower surface of a nut 183, which is threadedly connected to the upper reduced end of the spindle 160. The nut 183 may be locked in position by means of a suitable form of lock nut 184.

The piston 177 may advantageously be of the construction illustrated in Figure 12. As there shown, the piston has a wide lower portion 185 fitting snugly in the central portion of the cylinder, and a narrow upper portion 186 fitting snugly in the reduced upper portion of the cylinder. The lower portion of the piston may be hollowed out as at 187 to reduce the weight of the piston and may also be provided about its outer periphery with a number of annular grooves 188 and 189 and with a number of serrations 190. The narrow upper portion of the piston may be provided with a series of peripheral serrations 191 and with a number of vertical slots 192. The purpose of the annular grooves and serrations in the piston is to form a labyrinth packing as in the case of the guide and piston of the valves. The slots 192 permit air and steam to escape from the cylinder when the piston rises to prevent the pressure within the cylinder from building up.

The bottom of the cylinder 172 is closed by means of a plate 193. Between the piston 177 and the bottom plate 193 is provided a vertical cylindrical screen 194 for a purpose which will appear as the description proceeds. As shown, the bottom of the cylinder is provided at one side with an opening 195 for connection to the actuating line 149 from the pilot valve. Steam entering the cylinder 172 through the aperture 195 must pass through the screen, and hence any dirt that may be in the steam is kept out of the cylinder.

It is to be noted that the above described construction renders it possible to rotate the cross-bar or yoke 170 with the frame rods (not shown) as much as 180° to meet piping requirements.

It will be understood from the foregoing description that when the pilot valve pops, there will issue from the exhaust port 145 a jet of high velocity steam which will flow through the tubes 147 and 149 to the cylinder 172 of the pilot-actuated valve, and that this jet of steam will raise the piston 177 and the pin 178 against the cam surface 180 on the undersurface of the lever 179, thereby raising the valve disk 158 independently of the pressure under the valve disk. When the pilot valve closes, the flow of steam from the exhaust chamber ceases. The piston 177 then drops and the valve disk 158 is caused to return to its seat. It is to be noted that the valve disk 158 cannot seat itself before the pilot valve closes, due to the fact that the steam in the actuating line tends to expand. It is also to be noted that in case the pilot valve for some reason fails to function, the pilot-actuated valve will nevertheless operate to relieve excess pressure that may be built up under the valve disk 158.

As has been stated, the valves of Figures 6 and

12 are shown provided with a novel form of gag to be used when testing the valves. Referring to Figure 13 of the drawings, it will be noted that the gag, which is indicated generally by the numeral **200**, has a body portion in the form of a threaded rod **201** which terminates in a pointed lower end **202**. The rod **201** is shown provided at its upper portion with a flat fingerhold **203**.

The gag of the present invention is adapted to be used either with the conventional form of valve bonnet as shown in Figure 12 or with a special form of bonnet as shown in Figure 6. To adapt the conventional form of bonnet for use with the gag of the invention, it is merely necessary to provide a threaded aperture **204** in the top of the bonnet in alinement with the valve stem or spindle. This aperture can very easily be made while the bonnet is being machined. When the gag is not being used, the aperture may be closed by means of a suitable form of plug. (See numeral **43** in Figure 1).

The special form of bonnet is indicated in Figure 6 by the numeral **205**. As illustrated the bonnet is adapted to be substituted for the conventional bonnet and lever of the valve, and is provided at its top with a threaded aperture **206** in direct alinement with the valve stem or spindle. The bonnet **205** may be secured to the cross-bar **95** by means of the screws **207** and **208**.

To use the gag of the invention, it is merely necessary to insert the threaded body portion **201** through the threaded aperture in the top of the bonnet and to turn the gag by means of the fingerhold **203** to bring the pointed lower end **202** into a suitably formed aperture in the upper end of the spindle. No wrenches are required, it being merely necessary to tighten the gag by means of the fingers.

It will be understood from the foregoing description that the gag of the invention is very simple and inexpensive in construction, and that it affords a very effective way of gagging a valve for test purposes. The load is carried centrally of the valve stem or spindle and is so distributed that the lower pointed end **202** serves merely to guide the gag into the recess in the top of the stem or spindle. There is no tendency to bend the stem or spindle as when the cumbersome gag of the prior art is used.

In Figure 14, I have illustrated a suitable form of fluid system embodying several valves made in accordance with the teachings of the present invention. Referring to said figure of the drawings, the numeral **250** indicates the drum of a steam generating boiler, **251** are the coils of a superheater, **252** is a suitable connection between the drum **250** and the superheater coils, **253** is the superheater outlet line, and **254** is a suitable connection between the superheater **251** and the superheater outlet line **253**.

The letter A designates a pilot valve on the drum, B is a pilot-actuated valve on the superheater outlet line, C is a second drum valve which, however, is not a pilot valve, and D is a second superheater outlet valve, which may or may not be a pilot-actuated valve.

The valve A may be of the construction shown in Figure 11, and the valve B may be of the construction illustrated in Figure 12. Valves C and D may be of the constructions shown in Figures 1 to 6 inclusive. Neither valves A, B nor C are provided with bimetallic strips or clips. Valve D may be provided with the bimetallic elements, unless it is pilot-actuated.

The numeral **255** designates the actuating line from the exhaust belt of the pilot valve A to the cylinder **256** of the pilot-actuated valve B. This cylinder contains a piston (not shown) provided with a pin **257** which is in contact with the underside of the operating lever **258**. In case valve D is also to be pilot actuated, it should also be provided with a cylinder and piston as well as with a connection to actuating line **255**.

The numeral E denotes a gate valve connected to the drum **250** by means of a line **259** and to the actuating line **255** of the pilot-actuated valve B by means of the line **260**. The gate valve may be provided with suitable mechanical or electrical operating means and may be located in any convenient position, as for instance in the boiler room convenient to the chief engineer.

In the illustrative embodiment of the system shown in Figure 14, the pilot valve A may have a capacity of 8,000 pounds of steam per hour, a popping pressure of 610 pounds and a blow-down of 18 pounds; the pilot-actuated valve B may have a capacity of 45,000 pounds of steam per hour, a popping pressure of about 610 pounds and a blow-down of 18 pounds; valve C may have a capacity of 55,000 pounds of steam per hour, a popping pressure of 616 pounds and a blow-down of 18 pounds; and valve D may have a capacity of 38,000 pounds of steam per hour, a popping pressure of 618 pounds and a blow-down of 18 pounds.

It is thought that the operation of the system will be readily understood from the foregoing description. Suffice it to say, that if the system is operating normally and a heavy draft of steam is being taken from the outlet line, the pressure in the system will remain below the popping pressure and all of the valves will remain shut. Should, however, the call for steam cease, there will be a rapid build-up of pressure in both the superheater and in the saturated drum. Due to the normal drop in pressure between the drum and the superheater, the pilot valve A will normally pop first (i.e., as soon as the pressure under the valve disk in pilot valve A reaches 610 pounds). A small jet of steam from the exhaust belt of valve A will then be carried by the actuating line **255** to the cylinder **256** of pilot-actuated valve B, and the lever **258** thereof will be raised by the piston and valve B will also pop. If the popping of valves A and B does not relieve the pressure in the line sufficiently, then valve C will pop, and if the pressure is still not reduced sufficiently, valve D will also go. As soon as the pressure below the valve disk of the pilot valve drops by an amount equal to the blow-down, valve A will return to its seat, and valve B will follow. It is to be noted that valve B cannot seat before valve A due to the expansion of steam in the actuating line. In the illustrative system the lag between the closing of valves A and B is about ⅗ of a second. Valves C and D will close about the same time as valve B.

In case valve A for any reason fails to pop, valve B will nevertheless pop as soon as the popping pressure is reached below its valve disk. In case of an emergency, the chief engineer can readily open the gate valve E, thereby causing valve B to pop irrespective of the line pressure, and preventing the burning out of the superheater coils.

The gate valve E may, if desired, be connected to any one or more of the other valves in the system, so that the chief engineer may blow the connected valves at any time he considers such action necessary. It will be understood that each

safety valve to be connected to the gate valve should be provided with a cylinder and a piston as in the case of valve B.

From the foregoing description it will be seen that I have provided a valve of relatively simple construction, particularly adapted for service as a safety valve for pressure as high as 3000 pounds per square inch and temperatures as high as 1000° F., which may be readily adapted for use either as a pilot or pilot-actuated valve, which operates smoothly, sharply and without dirling, flutter, simmering (warn), chatter or seat drumming, which rises instantaneously to its full lift without any accumulation of pressure (overpressure), which closes abruptly at a relatively small drop in pressure below that at which the valve is set to pop, which always pops at substantially the same pressure, which is provided with means to regulate the blow-down, and with means to maintain the blow-down at the same value for both saturated and superheated steam, in which distortion of the valve disk and the valve seat is practically eliminated, in which the tearing action between the valve seat and the disk is reduced to a minimum, in which leakage between the seat ring and the body wall resulting from variable expansion and contraction is practically eliminated, in which the loading spring is protected from the fluid and from sudden and great changes of temperature as well as from the danger of overloading, in which undue stresses in the body or base of the valve are eliminated as well as the compressive strain on the throat tube, in which the throat tube and the valve body are protected from entrapped moisture and in which the collection of foreign materials tending to set up local centers for electrolytic action is eliminated.

In conclusion, it may be stated that various other modifications of the invention may be made, and that it is therefore to be understood that the invention is not to be considered as being limited by the specific examples herein given as illustrative of the invention, except as may be necessitated by the state of the prior art.

This application is a continuation in part of application Serial No. 31,011, filed July 12, 1935.

I claim:

1. A safety valve of the type described, comprising a valve body provided with a relief opening for connection with a tank adapted to contain fluid under pressure, said opening being provided about its periphery with an annular valve seat, a piston slidably mounted within said valve body in alinement with said relief opening and extending to the atmosphere, a valve disk carried by said piston in position normally to be seated against said valve seat, the body of said valve adjacent said relief opening being provided with an annular recess and with one or more apertures communicating with said recess, said piston being adapted to uncover said recess, said piston being provided with a serrated outer surface to form a labyrinth type of packing between said piston and the body of said valve, and adjustable means for controlling said apertures.

2. A safety valve of the type described, comprising a valve body provided with a relief opening for connection with a tank adapted to contain fluid under pressure, said opening being provided about its periphery with an annular valve seat, a cylindrical guide open to the atmosphere and extending into said body in substantial alinement with said relief opening, a cylindrical piston slidably mounted within said guide, a valve disk carried by said piston in position normally to be seated on said valve seat, said guide being provided near its lower end with an annular recess constituting an exhaust chamber and with one or more apertures in constant communication with said recess, said recess being adapted to be covered and uncovered by said piston in its slidable movement, and means for controlling said apertures.

3. In a safety valve, a valve body open at its top and provided with a flat annular seat, a cylindrical guide provided with an annular flange, said guide extending into said valve body and being suspended by its flange from said annular seat, a cup-shaped piston having a length substantially equal to that of the guide slidably mounted within said guide, said piston being provided with a recess in its bottom, a spindle extending through said piston into said recess, a valve disk mounted within said recess and carried by the lower end of said spindle, a spring washer mounted on said spindle above said valve body, a flanged sleeve freely suspended from said spindle below said spring washer, a loading spring coiled about said sleeve and confined between said washer and the flange of said sleeve, a throat tube in said valve body provided at its upper periphery with a valve seat, said valve disk being adapted to be seated normally on said valve seat.

4. A safety valve of the type described, comprising a valve body, a throat tube in said valve body provided at its upper periphery with a valve seat, a guide mounted in said valve body above said valve seat in fixed relation thereto, said guide being provided near one end with an annular recess forming an exhaust chamber and with one or more apertures in constant communication with said exhaust chamber, adjustable means to control said apertures, a piston slidably mounted within said guide and adapted to uncover said exhaust chamber, and a valve disk carried by said piston in position normally to be seated on said valve seat.

5. In a safety valve, a valve body open at its top and provided with a flat annular seat, a guide provided with an annular flange, said guide extending into said valve body and being suspended by its flange from said annular seat, said guide being provided near one end with an annular recess forming an exhaust chamber and with one or more apertures communicating with said exhaust chamber, adjustable means to control said apertures, a piston slidably mounted within said guide and adapted to uncover said exhaust chamber, a throat tube in said valve body below said piston, said throat tube being provided about its upper periphery with a valve seat, and a valve disk carried by said piston in position normally to be seated on said valve seat.

6. As a subcombination of a safety valve, a cylindrical guide, said guide being provided near one end with an annular recess forming an exhaust chamber and with one or more apertures constituting exhaust ports communicating with said recess or exhaust chamber, bimetallic strips associated with said exhaust ports for automatically closing said exhaust ports at a predetermined temperature, a cylindrical valve disk carrier mounted for slidable movement within said cylindrical guide and being movable to uncover said recess or exhaust chamber, and a valve disk carried by said carrier.

7. As a subcombination of a safety valve, a cylindrical guide, said guide being provided near

one end with an annular recess forming an exhaust chamber and with one or more apertures constituting exhaust ports communicating with said recess or exhaust chamber, adjustable means for controlling said exhaust ports, bimetallic strips associated with said exhaust ports for automatically closing said exhaust ports at a predetermined temperature, a cylindrical valve disk carrier mounted for slidable movement within said cylindrical guide and being movable to uncover said recess or exhaust chamber, and a valve disk carried by said carrier.

8. A safety valve of the type described, comprising a valve body provided with a relief opening for connection with a tank adapted to contain fluid under pressure, said opening being provided about its periphery with an annular valve seat, a piston slidably mounted within said valve body in alinement with said relief opening, a valve disk carried by said piston in position normally to be seated against said valve seat, the body of said valve adjacent said relief opening being provided with an annular recess forming an exhaust chamber and with one or more apertures constituting exhaust ports communicating with said recess or exhaust chamber, bimetallic strips associated with said exhaust ports to automatically close said exhaust ports at a predetermined temperature, said piston being adapted to cover and uncover said recess or exhaust chamber in its slidable movement.

9. A safety valve of the type described, comprising a valve body provided with a relief opening for connection with a tank adapted to contain fluid under pressure, said opening being provided about its periphery with an annular valve seat, a piston slidably mounted within said valve body in alinement with said relief opening, a valve disk carried by said piston in position normally to be seated against said valve seat, the body of said valve adjacent said relief opening being provided with an annular recess forming an exhaust chamber and with one or more apertures constituting exhaust ports communicating with said recess or exhaust chamber, adjustable means for controlling said exhaust ports, bimetallic strips associated with said exhaust ports to automatically close said exhaust ports at a predetermined temperature, said piston being adapted to cover and uncover said recess or exhaust chamber in its slidable movement.

10. A safety valve of the type described, comprising a valve body provided with a relief opening for connection with a tank adapted to contain fluid under pressure, said opening being provided about its periphery with an annular valve seat, a cylindrical guide disposed within said body in substantial alinement with said relief opening, a cylindrical piston slidably mounted within said guide, and a valve disk carried by said piston in position normally to be seated on said valve seat, said guide being provided near its lower end with an annular recess constituting an exhaust chamber, said recess being adapted to be covered and uncovered by said piston in its slidable movement, and the outer circumferential wall of said recess being provided with a plurality of exhaust ports, said recess and said exhaust ports being in constant communication.

11. A safety valve of the type described, comprising a valve body provided with a relief opening for connection with a tank adapted to contain fluid under pressure, said opening being provided about its periphery with an annular valve seat, a cylindrical guide disposed within said body in substantial alinement with said relief opening, a cylindrical piston slidably mounted within said guide, a valve disk carried by said piston in position normally to be seated on said valve seat, said guide being provided near its lower end with an annular recess constituting an exhaust chamber, said recess being adapted to be covered and uncovered by said piston in its slidable movement, and the outer circumferential wall of said recess being provided with a plurality of exhaust ports, and means for closing said exhaust ports at a predetermined temperature.

12. As a subcombination of a safety valve, a valve body open at its top and provided with a flat annular seat, a cylindrical guide provided with an annular flange, an adjusting ring clamping the flange of said cylindrical guide and being supported by said annular seat, said cylindrical guide extending into said valve body and being suspended by its flange from the adjusting ring, a piston slidably mounted within said guide, and a valve disk carried by said piston.

13. As a subcombination of a safety valve, a cylindrical guide, said guide being provided on its inner periphery near one end with an annular recess forming an exhaust chamber, said guide being provided on its outer periphery with one or more apertures in constant communication with said annular recess, adjustable means for controlling said apertures, a cylindrical piston mounted within said cylindrical guide, the outer periphery of said piston normally covering said annular recess, and said piston being adapted to be moved to uncover said annular recess, and a valve disk carried by said piston.

14. A safety valve of the type described, comprising a valve body provided with a relief opening for connection with a tank adapted to contain fluid under pressure, said opening being provided about its periphery with an annular valve seat, a tubular guide in substantial alinement with the relief opening, said guide being provided on its inner periphery at the end adjacent said relief opening with an annular recess forming an exhaust chamber, said guide being provided on its outer periphery with one or more apertures in constant communication with said annular recess, a piston mounted within said guide, the outer periphery of said piston normally covering said annular recess, and said piston being adapted to be moved to uncover said annular recess, and a valve disk carried by said piston and being normally seated against said valve seat, and when thus seated being disposed between said relief opening and said annular recess.

15. A safety valve of the type described, comprising a valve body provided with a relief opening for connection with a tank adapted to contain fluid under pressure, said opening being provided about its periphery with an annular valve seat, a tubular guide in substantial alinement with the relief opening, said guide being provided on its inner periphery at the end adjacent said relief opening with an annular recess forming an exhaust chamber, said annular recess being provided with one or more apertures communicating with the outer periphery of said guide, a piston mounted within said guide, and extending to the atmosphere, the outer periphery of said piston normally covering said annular recess, and said piston being adapted to be moved to uncover said annular recess, and a valve disk carried by said piston and being normally seated against said valve seat, and when

thus seated being disposed between said relief opening and said annular recess.

16. A safety valve of the type described, comprising a valve body provided with a relief opening for connection with a tank adapted to contain fluid under pressure, said opening being provided about its periphery with an annular valve seat, a tubular guide in substantial alinement with the relief opening, said guide being provided on its inner periphery at the end adjacent said relief opening with an annular recess forming an exhaust chamber, said annular recess being provided with one or more apertures communicating with the outer periphery of said guide, a piston mounted within said guide, said piston being provided with a serrated outer surface, the outer periphery of said piston normally covering said annular recess, and said piston being adapted to be moved to uncover said annular recess, and a valve disk carried by said piston and being normally seated against said valve seat, and when thus seated being disposed between said relief opening and said annular recess.

17. The safety valve defined in claim 14, one or more of the apertures in said annular recess being provided with metering valves to control the amount of steam escaping from said annular recess.

PERRY H. GENTZEL.

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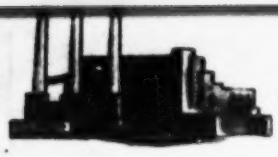
In the 267 new  **central station units being started in 40 different states during the 1953-56 period, 75% of the**

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